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# Sucrose Accumulation and Harvest Schedule Recommendations for CP Sugarcane Cultivars

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## Abstract

Sugarcane (*Saccharum* spp.) is harvested during a 5-month period (October to March) in the Everglades Agricultural Area (EAA) of south Florida. The genetic and temporal variability of sugarcane sucrose concentration is well established, but sucrose accumulation curves have not been reported for the Canal Point (CP) clones used in Florida since 1977. The objective of this study was to compare sucrose accumulation for recently released clones and provide harvest schedule recommendations based on this information. Thirteen CP clones were sampled at 2-week intervals throughout 4 consecutive harvest seasons. Based on seasonal changes in cultivar ranking in sugar per ton, recommended harvest scheduling relative to October 14 (time = 0 days) are: early-season (0 to 50 days) for cultivars CP 70-1133, CP 80-1743, and CP 88-1762; mid-season (50 to 100 days) for cultivars CP 78-1628 and CP 84-1198; and late-season (100 to 150 days) for cultivars CP 72-1210, CP 72-2086, CP 80-1827, CP 85-1382, CP 88-1508, and CP 89-2377. Sucrose accumulation in cultivar CP 89-2143 was greatest across all harvest periods and should be grown by Florida producers interested in improving the sucrose concentration of their crop.

## Introduction

Given present milling capacity in south Florida, a full 5 months (October to March) are required to process the 450,000 acres planted to sugarcane (*Saccharum* spp.). Sugarcane is grown in 4 counties (Glades, Hendry, Martin, and Palm Beach) in Florida, with the majority of the production area extending in a 30-mile wide arc from the south and east of Lake Okeechobee (Fig. 1). Some sugarcane must be harvested before achieving physiological maturity to sustain early-season (October to November) milling operations. "Early-maturing" cultivars are preferentially harvested during this time, recognizing that they may not have reached their peak sucrose content, but may have higher sucrose content than other later-maturing cultivars at the onset of mill operations (7).

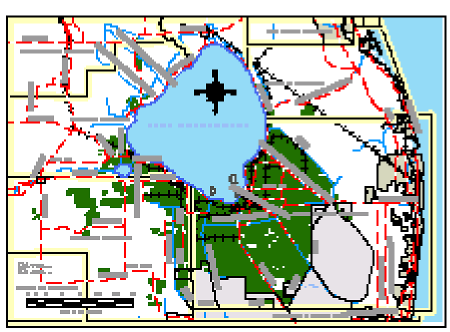


Fig. 1. Map of the sugarcane production area (green) in Florida.

Previous research has focused on the interaction of cultivar × date of sampling to produce sucrose content "maturity curves" in South Africa (1), Louisiana (3,4,9), and Mauritius (6). While the genetic variability of sugarcane sucrose accumulation rate has been well established, maturity curves for recently-released CP sugarcane clones bred at Canal Point, FL have not been reported since 1977 (7,8). CP clones account for greater than 70% of Florida sugarcane acreage, and are also economically important (11) in many countries including Argentina (25% of total acreage), Belize (16%), El Salvador (50%), Guatemala (65%), Honduras (47%), Mexico (15%), Morocco (54%), Nicaragua (75%), Senegal (9%), and Venezuela (9%). Although most sugarcane growers in Florida are now planting a diverse selection of newer cultivars, lack of maturity curves for these clones makes it difficult to make informed harvest scheduling decisions. The objective of this study was to use repeated sampling over time to compare sucrose accumulation characteristics among commercial CP cultivars in Florida, and to use this information to provide harvest scheduling recommendations for growers.

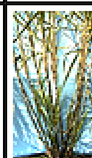
## Sampling CP Clones During Four Harvest Seasons

The data for this analysis were collected from a series of experiments conducted at 5 locations (University of Florida Everglades Research and Education Center, Hundley, Lakeview, Sundance, and Hillsboro farms) in the Everglades Agricultural Area of south Florida. Soil types included a Torry muck (euic, hyperthermic Typic Haplosaprist) for the Lakeview location and Lauderhill muck (euic, hyperthermic Lithic Haplosaprist) for the remaining 4 sites. Harvest data were collected from October to March during 4 consecutive seasons (1998-1999 to 2001-2002). All experiments were planted in a randomized block design with 3 or 4 replications with cultivar as the main treatment. Plots were 35 ft long and 5 rows wide with 5-ft row spacing. Five-stalk harvest samples were collected from each plot at approximately 2-week intervals, commencing on October 14 of each season and ending by March 27 the following year.

Each harvest sample was topped in the field, and the millable fresh stalk weight, Brix, and pol measured in the laboratory (*data not presented*). The fresh weight, Brix, and pol measurements were used (7) to calculate sugar per ton (SPT in lb/ton) of cane biomass for each cultivar and sampling date. A quadratic regression was performed in SAS (5) to generate regression relationships for SPT (Y-axis) versus harvest date (X-axis). For this discussion, harvest dates within any given season represent the number of days after October 14. Biweekly means and standard errors were calculated for each cultivar and sampling date. Intercept, linear, and quadratic coefficients describing SPT trends over time were analyzed with the GLM procedure in SAS to determine statistically significant differences (LSD values) between cultivars. Regression lines generated were used to describe SPT at 25 (early-season, November 8); 75 (mid-season, December 28); and 125 (late-season, February 16) days after onset of harvest for each cultivar.

Cultivars were selected for this study based on either their economic importance as documented in the most recent sugarcane census (2) or recent release date. The first two digits in the cultivar name represent the year the clone was named, usually 7 to 10 years prior to cultivar release. Table 1 provides a brief description of the cultivars included in this study. Cultivars are ordered by release date in tables and figures throughout this article. Cultivars are separated into 3 figures by year of introduction for ease in identifying individual clone sucrose accumulation patterns, but statistical comparisons were done between all clones included in this study.

Table 1. Florida sugarcane acreage and description of the CP clones included in this study.

| CP clone | 2001[a] acreage (% of total) | Description[b] and photo (click for larger view) |
|---|---|---|
| 70-1133 | 2.8 | Former widely-grown cultivar, slowly being phased out of industry due to low sugar content. |
| 72-1210 | < 1 | Former widely-grown cultivar phased out due to susceptibility to rust, yellow leaf virus, and ratoon stunting disease. |
| 72-2086 | 13.8 |  Widely adapted to S. Florida. Poor early growth but good post-freeze characteristics. |
| 78-1628 | 11.5 | Most widely-grown cultivar on mineral soils in Florida. |
| 80-1743 | 25.1 |  Vigorous tillering characteristics and well-adapted to mechanical harvest. Most widely-grown cultivar on muck soils (and overall) in Florida. |
| 80-1827 | 5.1 | Source of mechanically cut seed cane. Good post-freeze characteristics. |
| 84-1198 | 4.8 | Large stalk weight, easily uprooted. |
| 85-1382 | < 1 | Poor ratooning ability. Preferred host of West Indian Cane Weevil. |
| 88-1508 | < 1 | Very erect cultivar, low sugar content. |
| 88-1762 | 6.2 | Large stalk weight, high plant population, subject to lodging. |
| 88-1834 | < 1 | Susceptible to pineapple disease. |
| 89-2143 | 3.5 |  High sugar content and vigorous tillering characteristics. |
| 89-2377 | < 1 | High tonnage but brittle stalks. Resistant to ratoon stunting disease. |
| -- | Total acreage: ≈ 73% | -- |

[a] Source: (2).
[b] Source: (12).

## Sucrose Accumulation Curves

All regression coefficients describing sucrose accumulation maturity curves for each cultivar were significant at the $P < 0.001$ level (Table 2). "Early sugar" is an important characteristic that influences grower adoption of commercial germplasm. The intercept term ($\alpha$) represents clonal SPT on October 14 at the onset of the harvest season. Cultivars CP 80-1743, CP 88-1762, and CP 89-2143 were notable for their large intercept terms, which were significantly greater than 10, 8, and 11 cultivars, respectively, indicating that these clones would be good choices for October harvest in the EAA. In contrast, CP 88-1834 and CP 89-2377 had significantly lower intercepts than 11 of 12 cultivars, and thus would be poor choices for early harvest. Regression equations were also used to calculate optimal harvest dates based on maximum SPT for each cultivar (Table 2). These dates ranged from January 26 (CP 80-1743 and CP 88-1762) to February 22 (CP 85-1382). Maximum SPT ranged from 267 lb/ton (CP 88-1834) to 308 lb/ton (CP 89-2143). Miller and James (7) reported maximum SPT for 6 cultivars at dates ranging from February 24 to May 17. The maximum SPT averaged for the 6 cultivars in their study was 281 lb/ton compared to 279 lb/ton for the 13 cultivars included in this study. It appears that maximum SPT for CP cultivars has not changed greatly over the last 25 years, but the date of maximum SPT has shifted earlier in the harvest season. An exception to this is CP 89-2143, which has raised the standard for SPT levels significantly in recent years, causing lower SPT cultivars to become less acceptable to growers.

Table 2. Regression coefficients[a] describing sugar per ton (SPT, lbs sucrose per ton) accumulation over time (maturity curves) for recently-released CP sugarcane clones.

| CP clone | *n* | α | β | γ | $R^2$ | Maximum SPT | Maximum SPT date |
|---|---|---|---|---|---|---|---|
| 70-1133 | 446 | 207 | 1.10 | -0.0049 | 0.37 | 268 | Feb 2 |
| 72-1210 | 618 | 195 | 1.59 | -0.0072 | 0.53 | 283 | Feb 1 |
| 72-2086 | 647 | 204 | 1.38 | -0.0056 | 0.61 | 290 | Feb 14 |
| 78-1628 | 453 | 207 | 1.52 | -0.0071 | 0.50 | 288 | Jan 28 |
| 80-1743 | 748 | 219 | 1.05 | -0.0051 | 0.26 | 274 | Jan 26 |
| 80-1827 | 447 | 209 | 1.08 | -0.0041 | 0.44 | 279 | Feb 21 |
| 84-1198 | 647 | 197 | 1.45 | -0.0066 | 0.36 | 276 | Feb 1 |
| 85-1382 | 646 | 199 | 1.10 | -0.0042 | 0.41 | 272 | Feb 22 |
| 88-1508 | 447 | 204 | 1.28 | -0.0054 | 0.53 | 279 | Feb 10 |
| 88-1762 | 751 | 215 | 1.27 | -0.0061 | 0.43 | 282 | Jan 26 |
| 88-1834 | 603 | 171 | 1.62 | -0.0068 | 0.52 | 267 | Feb 9 |
| 89-2143 | 623 | 223 | 1.40 | -0.0058 | 0.64 | 308 | Feb 11 |
| 89-2377 | 647 | 171 | 1.71 | -0.0072 | 0.58 | 273 | Feb 10 |
| LSD 0.05 | -- | 8.2 | 0.12 | 0.0015 | -- | -- | -- |

[a] $Y = \alpha + \beta X + \gamma X^2$, where Y = sugar per ton and X = harvest date, specifically number of days after October 14.

Maturity curves are presented for cultivars included in this study in Figs. 2, 3, and 4. CP cultivars named from 1970 to 1979 are included in Fig. 2, cultivars named from 1980 to 1985 in Fig. 3, and cultivars named from 1986 to 1990 in Fig. 4. At the first sampling date, CP 70-1133 SPT was greater than or equal to that of CP 72-1210, CP 72-2086, and CP 78-1628, but thereafter SPT for CP 70-1133 increased at a notably slower rate over time (Fig. 2). In contrast, the SPT of CP 72-2086 exceeded these clones during the late-season harvest period. CP 72-2086, used as a check in the CP breeding program, is known for slow early-season growth, but has maintained its acreage in the EAA due to favorable late-season performance. CP 80-1743 recorded superior early-season SPT compared to other clones named from 1980 to 1985 (Fig. 3), but its relative SPT ranking decreased as the harvest season progressed. CP 89-2143 had clearly superior SPT compared to other cultivars at all 11 sampling dates (Fig. 4). CP 88-1834 and CP 89-2377 were notable for their poor SPT, particularly during the early-season.

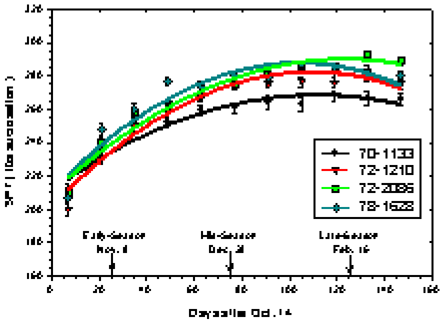


Fig. 2. Sugar per ton (Y) versus harvest date (X) for CP clones 70-1133, 72-1210, 72-2086, and 78-1628.

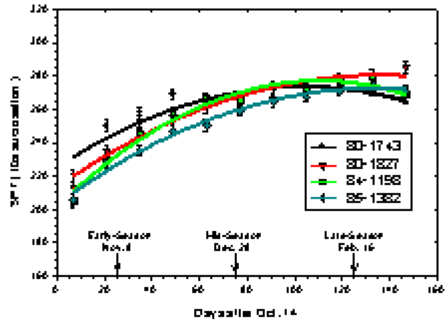


Fig. 3. Sugar per ton (Y) versus harvest date (X) for CP clones 80-1743, 80-1827, 84-1198, and 85-1382.

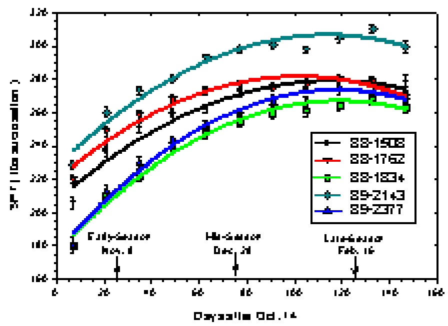


Fig. 4. Sugar per ton (Y) versus harvest date (X) for CP clones 88-1508, 88-1762, 88-1834, 89-2143, and 89-2377.

## Harvest Recommendations for 13 CP Clones

Sugarcane farmers in the EAA typically grow several cultivars concurrently in different fields. While the calculation of maturity curves for individual clones is informative, the relative ranking of a given cultivar in comparison to others is required to optimize harvest scheduling decisions. Table 3 presents SPT for each cultivar for early-season (25 days after October 14), mid-season (75 days), and late-season (125 days) harvest dates, along with the cultivar ranking for each harvest period. The final column represents harvest schedule recommendations based on the change in cultivar ranking over time. For example, since the relative ranking of CP 70-1133 was highest early in the season (rank = 8) compared to mid-season (rank = 10) or late-season (rank = 12), CP 70-1133 receives an early-season harvest recommendation. Other cultivars that are recommended for early harvest based on these criteria are CP 80-1743 and CP 88-1762. Cultivars that had their highest rank in mid-season included CP 78-1628 and CP 84-1198. Late-maturing cultivars included CP 72-1210, CP 72-2086, CP 80-1827, CP 88-1508, and CP 89-2377. The ranks of CP 89-2143 (first) and CP 88-1834 (last) remained consistent throughout all harvest periods. CP 89-2143 should be planted by growers interested in increasing the sucrose content of their sugarcane crop, while CP 88-1834 is a poor choice for sugar production in the EAA. While the consistently high rank of CP 89-2143 would suggest that it could be harvested throughout the season, its excellent post-freeze characteristics (10) compared to other commercial cultivars indicate that it should be reserved for late harvest.

Table 3. Cultivar SPT (lbs sucrose per ton) and rank at 25 (early-season), 75 (mid-season) and 125 (late-season) days after onset of the harvest season in Florida, and harvest recommendation based on change in cultivar rank.

| CP clone | SPT | Rank[a] | SPT | Rank | SPT | Rank | Harvest period recommendation |
|---|---|---|---|---|---|---|---|
| | 25 days | | 75 days | | 125 days | | |
| 70-1133 | 231.4 | 8 | 261.8 | 10 | 267.6 | 12 | early |
| 72-1210 | 230.3 | 9 | 273.7 | 5 | 281.2 | 4 | late |
| 72-2086 | 235.3 | 5 | 276.5 | 4 | 289.8 | 2 | late |
| 78-1628 | 240.5 | 4 | 280.7 | 2 | 285.2 | 3 | middle |
| 80-1743 | 242.4 | 3 | 269.8 | 6 | 272.0 | 10 | early |
| 80-1827 | 233.2 | 6 | 266.6 | 9 | 279.3 | 5 | late |
| 84-1198 | 228.9 | 10 | 268.4 | 8 | 275.0 | 8 | middle/late |
| 85-1382 | 224.2 | 11 | 258.2 | 12 | 271.4 | 11 | early/late |
| 88-1508 | 232.1 | 7 | 269.1 | 7 | 279.3 | 6 | late |
| 88-1762 | 243.4 | 2 | 276.6 | 3 | 279.2 | 7 | early |
| 88-1834 | 206.8 | 13 | 253.6 | 13 | 266.3 | 13 | none recommended |
| 89-2143 | 254.7 | 1 | 295.6 | 1 | 307.6 | 1 | early, middle & late[b] |
| 89-2377 | 209.6 | 12 | 259.3 | 11 | 273.0 | 9 | late |
| LSD 0.05 | 5.5 | | 3.4 | | 2.0 | | -- |

[a] Rank: 1 = highest, 13 = lowest.

[b] Late harvest preferred due to excellent post-freeze characteristics.

The most current grower census (2) indicates that the 3 clones with the highest early SPT rankings, (CP 89-2143, CP 88-1762, and CP 80-1743), are also the clones with the greatest expansion in plant cane acreage. In contrast, recently-released clones with poor early-season SPT (CP 88-1834 and CP 89-2377) have been planted on < 1% of the Florida sugarcane acreage. Clones with < 1% acreage in the latest census (CP 72-1210, CP 85-1382, CP 88-1508, CP 88-1834, and CP 89-2377) had an average SPT of 188 lb/ton in mid-October, while the remaining 8 cultivars in this study (with higher adoption rates) averaged 210 lb/ton. Growers are factoring SPT trends into their cultivar planting decisions. Maturity curve information contained in this study will provide growers with a tool to make informed harvest scheduling decisions for these cultivars.

## Conclusions

Considerable genetic and temporal variability underlying sucrose accumulation trends was documented for CP sugarcane clones. While this analysis has focused on crop management recommendations in Florida, the methodology presented could be used to produce harvest schedule recommendations wherever sugarcane cultivars are grown. For the group of 8 CP cultivars included in this study commercially grown in Florida, growers are advised to harvest CP 70-1133, CP 80-1743, and CP 88-1762 in the early-season; CP 78-1628 and CP 84-1198 mid-season; and CP 72-2086 and CP 80-1827 in the late-season. CP 89-2143 has superior SPT throughout the 5-month harvest season, and should be planted by growers interested in increasing sucrose concentration of their sugarcane crop.

## Acknowledgments

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